Biological pretreatment and dry digestion processes for biogas production

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Abstract

Biogas technology has been used quite extensively to generate renewable energy from organic wastes while also recycling nutrients in the wastes and reducing harmful emissions. However, the challenges of low biogas yield from recalcitrant and inhibitory solid wastes together with high construction and operation costs of bioreactors have impeded optimal performance through this process. Additionally, solid organic wastes with total solids (TS) contents greater than 20 % are produced daily in enormous amounts; treating these wastes in conventional wet anaerobic digestion processes has required the addition of water, leading to large reactor volumes, high energy costs for heating, and costly dewatering processes for the digestate residue. In this study, the challenges mentioned above were addressed by using biological pretreatment and dry anaerobic digestion processes. Pretreatment, non-pretreatment strategies, biogas bioreactors design were also studied since this will aid optimizing its economy.

The suitability of a novel textile bioreactor for biogas production was accessed in dry digestion process (dry-AD) treating manure bedded with straw (22 – 30 %TS of feedstock). The 90-L textile bioreactor was robust and simple to operate; it can be accessed easily by developing countries where required expertise may not be available. Methane yield from the manure with straw was 290 NmlCH_4/gVS using acclimatised bacteria; the digestate residue was affirmed suitable as bio-fertiliser. The efficiency of continuous plug flow reactor for dry anaerobic digestion of manure bedded with straw was also investigated at 22 %TS. Organic loading rates up to 4.2 gVS/L/d with retention time of 40 days gave better process stability.

Recalcitrant structure of chicken feather wastes was altered using *Bacillus* sp. C4 (*Bacillus pumilus*) and this pretreatment improved methane yield by 124 % compared to the untreated. Considering the fact that easily degraded feedstocks are not highly available and some problems associated with pretreatments: dry anaerobic co-digestion of citrus wastes with chicken feathers, wheat straw and manure bedded with straw, was investigated at 20 %TS in batch process. The best mixing ratio enhanced methane yield by 14 % compared to the expected yield from individual fractions. Process performance at different organic loading rates (OLR) was then investigated in continuous plug flow reactors at 21 %TS and 32 %TS of feedstock. Stability of the process decline as OLR was increased to 3.8 gVS/l/d resulting in high total volatile fatty acids (VFA), VFA/alkalinity ratio and reduction in methane yield.

Keywords: *Solid wastes; Dry anaerobic digestion; Textile bioreactor; Plug flow bioreactor; Digestate; Process stability; Pretreatment; Co-digestion; Mesophilic*